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DESICCATOR BOX FOR USE IN MICROWAVE COMPONENT TESTING

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This report describes a low-cost, portable, network analyzer desiccator box. The box was designed to remove humidity as a variable from network analyzer tests of humidity-sensitive microwave devices.

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CONTENTS

FIGURES

AN UNCONTROLLED TEST VARIABLE: HUMIDITY

Good test procedures should strive to control as many variables as possible. Microwave electronics, both passive and active, are examples of where this applies. At very high frequencies (1 GHz to 300 GHz) or microwave frequencies many variables affect the performance of microwave circuits and components. These variables include: temperature of the device under test (DUT), humidity, power delivered, power dissipated, integrity of test equipment, ground problems, EMI (electromagnetic interference), static discharge, light radiation, bias, and others. Although few of these variables are overlooked during testing, one is constantly neglected, and that is: humidity. The amount of humidity (H_2O vapor) in a test area can vary greatly from experiment to experiment. Microwave circuits and components are presently tested by using a vector network analyzer. The network analyzer gives the user a means of measuring the frequency response (both magnitude and phase) of microwave components over a wide frequency range. Using a vector network analyzer and good test practice, the tester can control many unknown variables; however, humidity is often not controlled during these tests. The problem is that humidity (or water vapor) has adverse effects on microwave circuits and components.

Humidity presents a problem at microwave frequencies because water molecules resonate at 22 GHz [1]. Microwave components either absorb water vapor into their structure or the vapor may absorb onto the surface of the components. In either case, loss occurs because the electric fields stimulate dipole motion in the water. Although the main power absorption due to water vapor is at 22 GHz, the loss extends below 22 GHz in continually decreasing amounts. This small amount of attenuation at lower frequencies can be ignored in circuits with moderate loss, but in very low loss or high

1. Electronics Engineers' Handbook, First edition, edited by D.G. Fink, McGraw-Hill company, 1975, Sec. 18, p.87

quality factor, Q , circuits (e.g., resonators) the effect could reduce the Q by a significant amount. Microwave components, such as dielectric resonators, ferrites, ferroelectrics, and microstrip circuits constructed on Teflon dielectrics can all absorb small amounts of water vapor and thus develop unnecessary loss. If a ring resonator is constructed on Teflon dielectric microstrip and is tested in a humid environment, the loss of the circuit will go up, thus lowering the measured Q of the resonator. The motivating reason to develop a desiccator box is to remove humidity as an uncontrolled variable during network analysis measurements.

DESICCATOR TEST BOX FEATURES

One solution to humidity during network analysis tests is a controlled test environment with very low humidity, in the form of a desiccator box with the following performance features:

- Permits slow, even purge of room air
- Allows dry gas purge
- Permits transmission lines to pass into and out of the box in order to test the device with a network analyzer
- Allows bias leads to pass into box
- Allows flexibility in testing of various size devices
- Has window for viewing device under test
- Has a gasket that allows easy opening and closing
- Operates easily
- Is portable
- Has low cost

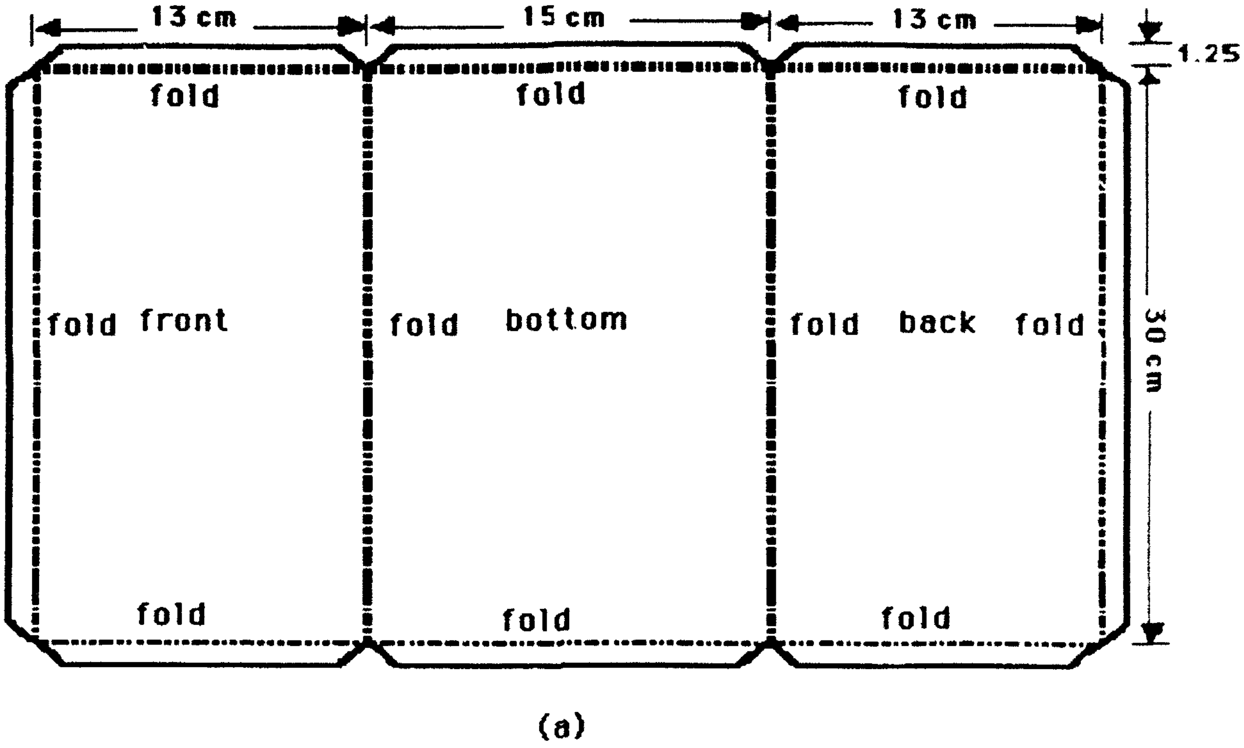
DETAILS OF DESICCATOR BOX ASSEMBLIES

The Desiccator Main Body

The main body of the desiccator box is constructed from a piece of sheet metal (see Figure 1a). The sheet metal is folded into a bottom and two sides, or front and back. On the edges of the top and sides, 1.25-cm tabs are folded (see Figure 1b). These tabs serve two functions: (1) the ones on the ends support the foam walls and help retain them from blowing outward, and (2) they serve as tabs on the top of the desiccator box for the lid to rest on and seal against .

Purging System

There must be a slow purge of humid room air out of the desiccator box in order to reduce abrupt changes in the environment (temperature and turbulence) of the sensitive DUT. The purge of the humid air must also be even; this is necessary to ensure that there is no turbulence in the desiccator box producing a "dead" spot where room air may be trapped. This problem is solved by using porous foam rubber and a controllable flow of dry nitrogen gas (N_2). The porous foam rubber is approximately 3 cm thick. The two pieces of foam are glued in place with silicon rubber sealant (see Figure 2). A hole is cut in the front wall of the desiccator box and a hollow bolt is inserted and secured to the desiccator box with nuts on the outside and inside of the front wall (see Figure 2). A rubber hose is connected between the bolt and the controllable N_2 gas source. Conceptually, what we now have is a solid box on two sides, top, and bottom, with foam walls on the two ends, and an N_2 gas inlet. When the N_2 gas is allowed to flow slowly into the desiccator box through the gas inlet, the foam naturally distributes the pressure over its inside surface and slowly allows the gas to pass through. The end result is an environment where there is a slow and even purge of the air that was in the desiccator box when N_2 gas is allowed to flow in



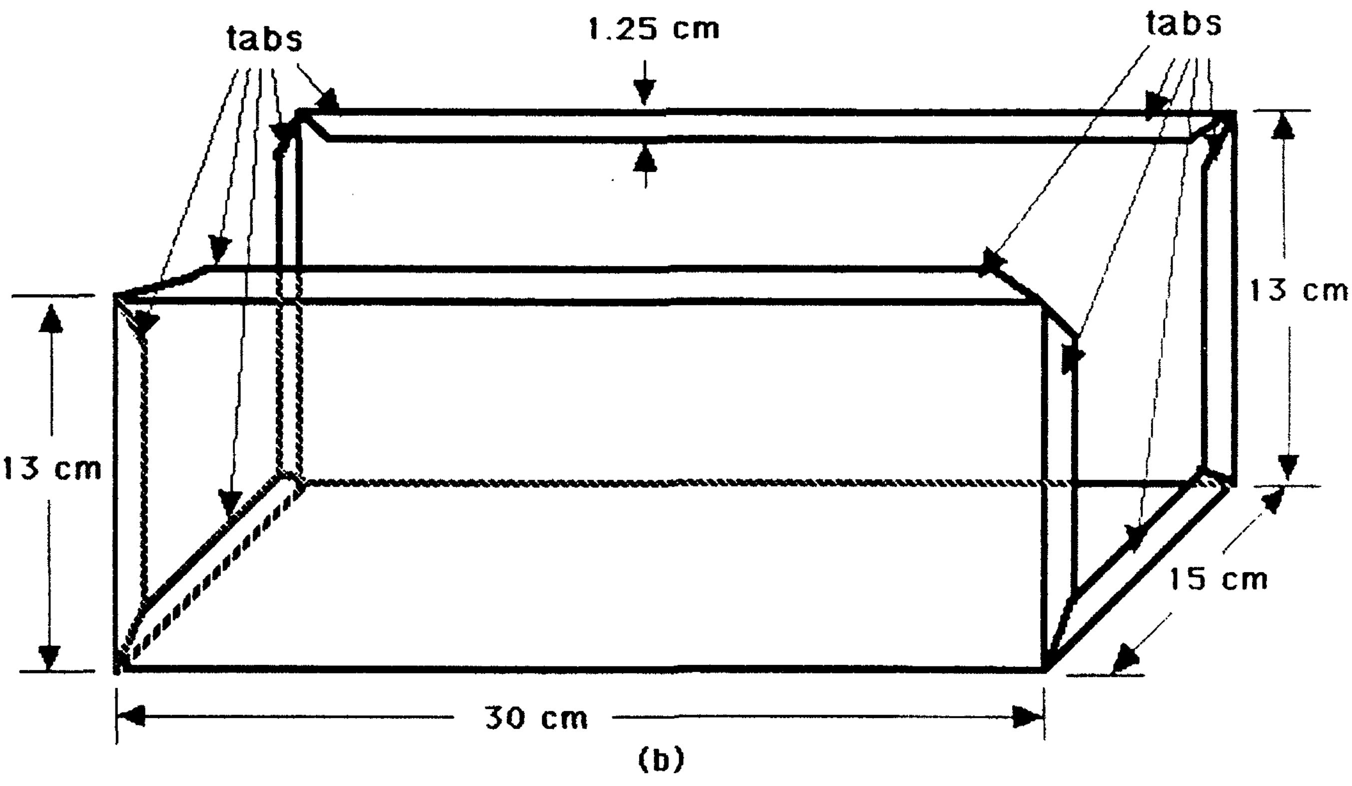


Figure 1. Desiccator box main body. (a) Sheet metal layout. (b) Folded sheet metal box.

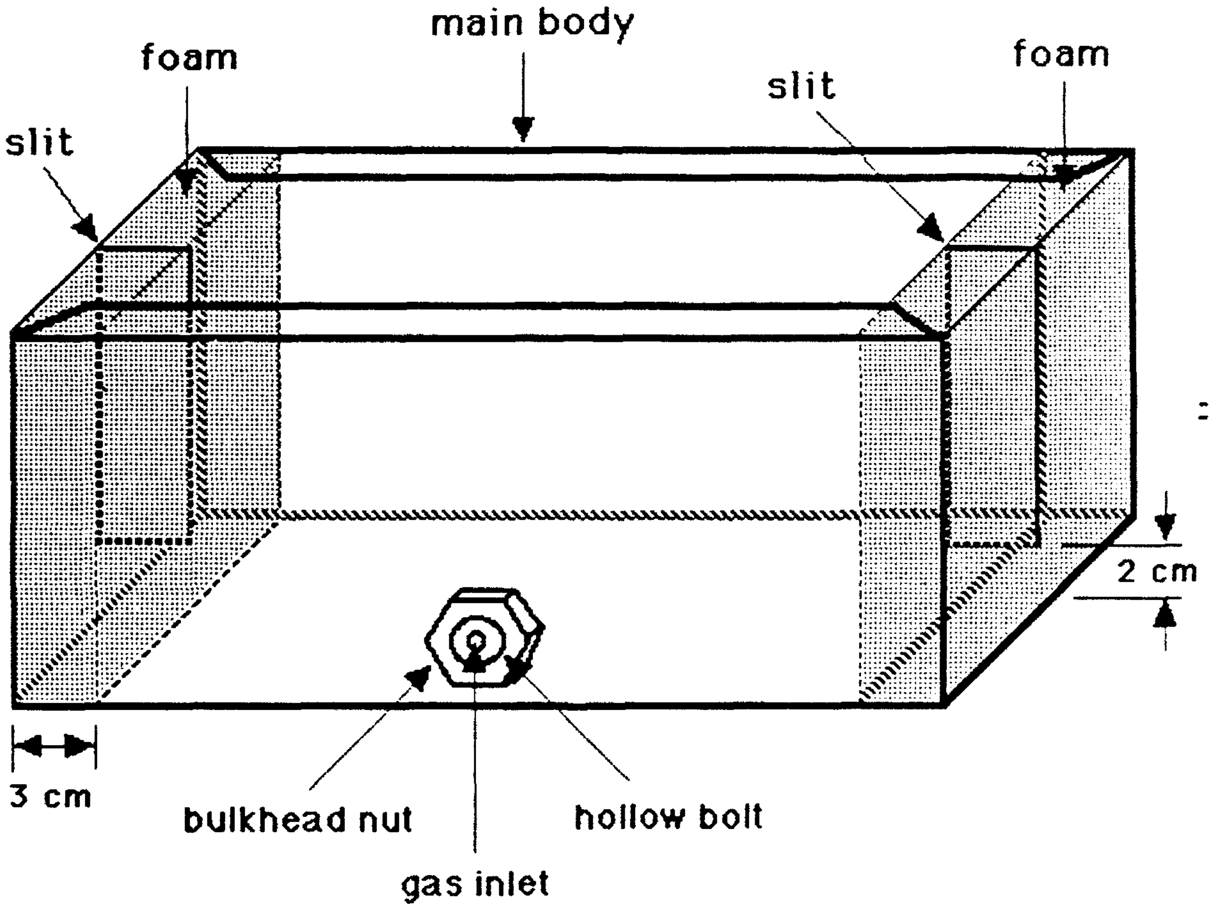


Figure 2. Desiccator box with foam walls, slits, and gas inlet.

the gas inlet. The atmosphere inside the desiccator box must be kept dry and humidity free; this is accomplished by keeping a small but constant positive gas pressure on the inside of the desiccator box. A constant dry gas purge of the box prevents humid room air from flowing back into the desiccator box through the foam.

Connection to Network Analyzer

In order to test microwave circuits and components, a vector network analyzer is the state-of-the-art test instrument. This two port measurement system requires the DUT to be connected to two coaxial cables that are connected to the network analyzer. At higher frequencies (40 GHz and above), waveguide may be substituted for the coaxial line. In both cases, some sort of transmission line must be connected between the network analyzer and the DUT. In order to eliminate the humidity problem while testing devices, a desiccator box must allow transmission lines to pass into and out of it. The solution to this problem was to cut slits in the foam rubber walls that are at either end of the desiccator box, and to create a removable top for the box (see Figures 2, 3, and 4). The slits run three-fourths of the way down the foam rubber walls, starting at the top but stopping 2 cm from the bottom. The transmission lines can pass through the slits in the foam and not allow any gas leaks, because the foam rubber conforms to the shape of the transmission lines, thus creating a seal around the transmission lines. Biasing lines for active circuits can also be run through these self-sealing slits.

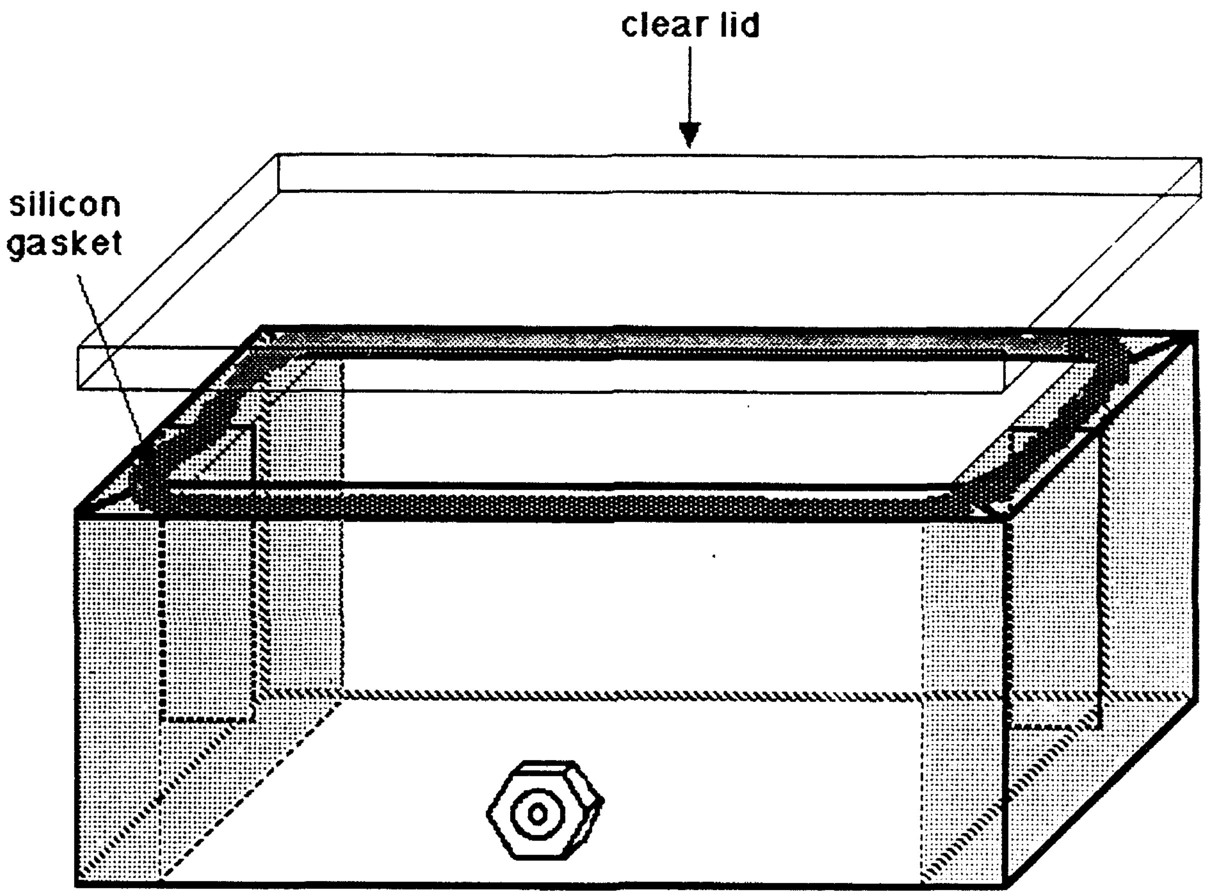


Figure 3. Desiccator box with lid and silicon gasket.

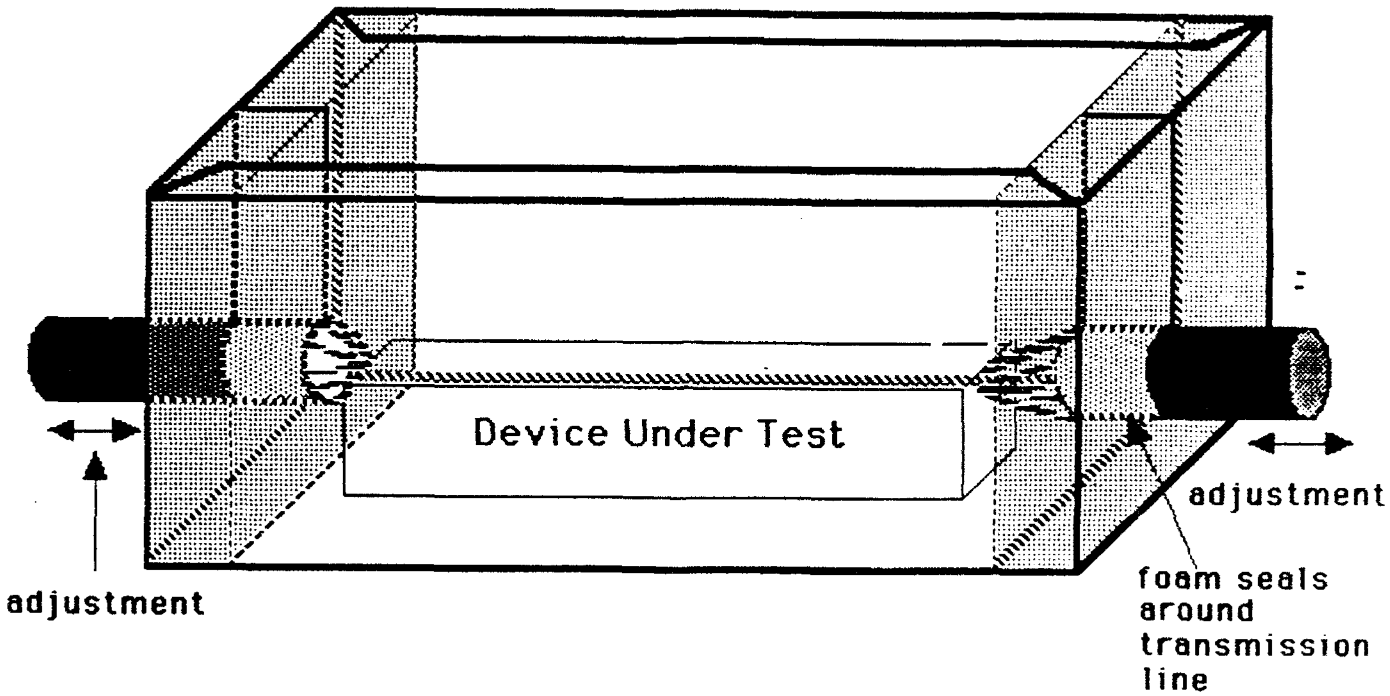


Figure 4. Desiccator box with Device under test and transmission lines.

Desiccator Lid and Window

A window for viewing the DUT is necessary, because it is important to make sure that nothing has visibly changed in the circuit. This helps remove any suspicion about the integrity of the test (e.g., loose bias lines). The removable top was constructed from a clear acrylic sheet 0.7 cm thick, and machined to have smooth edges; it fits squarely on top of the box. The lid is supported by the top of the foam and the flanges on the top edge of the sheet metal body. With these features you can connect the DUT to the transmission lines and the network analyzer and then lower the DUT and transmission lines into the box from the top. The lid is then placed on top. The design of the desiccator box must be flexible in order to test circuits of varying dimensions. Due to unforeseen dimensions of devices, a size limitation cannot be placed on circuit size. This design requirement is met by the 30-cm length and 15-cm width of the desiccator box. The foam rubber walls with slits in them allow the transmission lines to be moved in and out of the box, thus allowing short and long circuits to be tested (up to 25 cm long and 15 cm wide); see Figure 4.

Lid Gasket

On the upper edge of the top of the desiccator box, a 0.5 cm thick layer of silicon rubber is spread, in such a way as to create a seal between the top of the desiccator box and the lid (see Figure 3). This gasket allows easy opening and closing of the lid and assures an airtight seal.

TEST PROCEDURE

The lid is placed on the desiccator box and the N_2 inlet connected to the N_2 source. The source is then turned on and the box purged for one minute. Next the DUT is removed from its desiccated transportation container and connected to the network analyzer's transmission lines. The lid is removed from the desiccator box, and the DUT is lowered into the box. The transmission lines are guided in the slots and slide down along with the DUT; the lid is then replaced on the desiccator box. The "dry" atmosphere can then be maintained with a small amount of gas flow.

SUMMARY

Good test procedures should strive to control as many variables as possible. With the use of this desiccator box, humidity can now be eliminated as a test variable, thus improving, performance, stability, and repeatability of microwave circuits under test by a vector network analyzer.

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